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# Teaching Science through Inquiry. ERIC/CSMEE Digest.

"If a single word had to be chosen to describe the goals of science educators during the 30-year period that began in the late 1950s, it would have to be INQUIRY." (DeBoer, 1991, p. 206).

In a statement of shared principles, the U.S. Department of Education and the National Science Foundation (1992) together endorsed mathematics and science curricula that "promote active learning, inquiry, problem solving, cooperative learning, and other instructional methods that motivate students." Likewise, the National Committee on Science Education Standards and Assessment (1992) has said that "school science education must reflect science as it is practiced," and that one goal of science education is "to prepare students who understand the modes of reasoning of scientific inquiry and can use them." More specifically, "students need to have many and varied opportunities for collecting, sorting and cataloging; observing, note taking and sketching; interviewing, polling, and surveying" (Rutherford & Algren, 1990).

## DISTINGUISHING FEATURES OF INQUIRY-ORIENTED SCIENCE INSTRUCTION

Inquiry-oriented science instruction has been characterized in a variety of ways over the years (Collins, 1986; DeBoer, 1991; Rakow, 1986) and promoted from a variety of perspectives. Some have emphasized the active nature of student involvement, associating inquiry with "hands-on" learning and experiential or activity-based instruction. Others have linked inquiry with a discovery approach or with development of process skills associated with "the scientific method." Though these various concepts are interrelated, inquiry-oriented instruction is not synonymous with any of them.

From a science perspective, inquiry-oriented instruction engages students in the investigative nature of science. As Novak suggested some time ago (1964), "Inquiry is the [set] of behaviors involved in the struggle of human beings for reasonable explanations of phenomena about which they are curious." So, inquiry involves activity and skills, but the focus is on the active search for knowledge or understanding to satisfy a curiosity.

Teachers vary considerably in how they attempt to engage students in the active search for knowledge; some advocate structured methods of guided inquiry (Igelsrud & Leonard, 1988) while others advocate providing students with few instructions (Tinnesand & Chan, 1987). Others promote the use of heuristic devices to aid skill development (Germann, 1991). A focus on inquiry always involves, though, collection and interpretation of information in response to wondering and exploring.

From a pedagogical perspective, inquiry-oriented teaching is often contrasted with more traditional expository methods and reflects the constructivist model of learning, often referred to as active learning, so strongly held among science educators today. According to constructivist models, learning is the result of ongoing changes in our mental frameworks as we attempt to make meaning out of our experiences (Osborne & Freyberg, 1985). In classrooms where students are encouraged to make meaning, they are generally involved in "developing and restructuring [their] knowledge schemes through experiences with phenomena, through exploratory talk and teacher intervention" (Driver, 1989). Indeed, research findings indicate that, "students are likely to begin to understand the natural world if they work directly with natural phenomena, using their senses to observe and using instruments to extend the power of their senses" (National Science Board, 1991, p. 27).

In its essence, then, inquiry-oriented teaching engages students in investigations to satisfy curiosities, with curiosities being satisfied when individuals have constructed mental frameworks that adequately explain their experiences. One implication is that inquiry-oriented teaching begins or at least involves stimulating curiosity or provoking wonder. There is no authentic investigation or meaningful learning if there is no inquiring mind seeking an answer, solution, explanation, or decision.

## THE BENEFITS OF TEACHING THROUGH INQUIRY

Though some have raised concerns about extravagant claims made for science instruction based on activities and laboratory work (Hodson, 1990), studies of inquiry-oriented teaching (Anderson et al., 1982) and inquiry-based programs of the 1960s (Mechling & Oliver, 1983; Shymansky et al., 1990) have been generally supportive of inquiry approaches. Inquiry-based programs at the middle-school grades have been found to generally enhance student performance, particularly as it relates to laboratory skills and skills of graphing and interpreting data (Mattheis & Nakayama, 1988). Evidence has also been reported that shows inquiry-related teaching effective in fostering scientific literacy and understanding of science processes (Lindberg, 1990), vocabulary knowledge and conceptual understanding (Lloyd & Contreras, 1985, 1987), critical thinking (Narode et al., 1987), positive attitudes toward science (Kyle et al., 1985; Rakow, 1986), higher achievement on tests of procedural knowledge (Glasson, 1989), and construction of logico-mathematical knowledge (Staver, 1986).

It seems particularly important that inquiry-oriented teaching may be especially valuable for many underserved and underrepresented populations. In one study, language-minority students were found to acquire scientific ways of thinking, talking, and writing through inquiry-oriented teaching (Rosebery et al., 1990). Inquiry-oriented science teaching was shown to promote development of classification skills and oral communication skills among bilingual third graders (Rodriguez & Bethel, 1983). Active explorations in science have been advocated for teaching deaf students (Chira, 1990). Finally, experiential instructional approaches using ordinary life experiences are considered to be more compatible with native American viewpoints than are text-based approaches (Taylor, 1988).

Caution must be used, however, in interpreting reported findings. There is evidence of interactions among investigative approaches to science teaching and teaching styles (Lock, 1990), and the effects of directed inquiry on student performance may vary by level of cognitive development (Germann, 1989). There seems also a possible conflict of goals when attempting to balance the needs of underachieving gifted students to develop more positive self-concepts with the desire to develop skills of inquiry and problem solving (Wolfe, 1990).

It must also be emphasized that an emphasis on inquiry-oriented teaching does not necessarily preclude the use of textbooks or other instructional materials. The Biological Sciences Curriculum Study materials are examples of those that include an inquiry orientation (Hall & McCurdy, 1990; Sarther, 1991). Other materials accommodating an inquiry approach to teaching have been identified by Haury (1992). Several elementary school textbooks have been compared (Staver & Bay, 1987) and a content analysis scheme for identifying inquiry-friendly textbooks has been described (Tamir, 1985). Duschl (1986) has described how textbooks can be used to support inquiry-oriented science teaching. As mentioned by Hooker (1879, p. ii) many years ago, "No text-book is rightly constructed that does not excite [the] spirit of inquiry."

As instructional technology advances, there will become more options for using a variety of materials to enrich inquiry-oriented teaching. Use of interactive media in inquiry-based learning is being examined (Litchfield & Mattson, 1989), and new materials are being produced and tested (Dawson, 1991). Use of computerized data-bases to facilitate development of inquiry skills has also been studied (Maor, 1991).

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